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#8/Translation of Priority Papers

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Title: INTERNAL EGR QUANTITY ESTIMATION, CYLINDER INTAKE AIR QUANTITY CALCULATION, VALVE TIMING CONTROL, AND IGNITION TIMING CONTROL

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Sir:

Further to Applicants' claim of priority under 35 U.S.C. 119 from foreign application, Japanese Patent Application No. 11-344216, filed December 3, 1999, submitted herewith is an English translation of said original foreign application, and a certificate from the translator of the accuracy of the translation.

Respectfully submitted,

Date October 3, 2002

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I, Tsuyoshi Suzuki, residing at 2-707, 1608-1, Shimotsuruma, Yamato-shi, Kanagawa 242-0001 Japan, and working for ISP Corporation of 1-29, Akashi-cho, Chuo-ku, Tokyo 104-0044, Japan, fully conversant with the English and Japanese languages, do hereby certify that to the best of my knowledge and belief the following is a true translation of Japanese Patent Application No. 11-344216 filed in the Japanese Patent Office on the 3rd day of December, 1999 in respect of an application for Letters Patent.

Signed, this 5th day of September, 2002

Tsuyoshi Suzuki

[Name of Document] SPECIFICATION

[Title of the Invention] VARIABLE VALVE CONTROL UNIT

[Claims]

[Claim 1] A variable valve control unit being capable of variably controlling the opening and closing timings of the intake and exhaust valves of an engine as desired, characterized in that the control unit is configured to estimate the internal EGR quantity based on the state of engine operation and to control the closing timing of the intake valve based on the required intake air quantity of the engine and the estimated internal EGR quantity.

[Claim 2] A variable valve control unit being capable of variably controlling the opening and closing timings of the intake and exhaust valves of an engine as desired, comprising:

target air quantity calculating means for calculating the target air quantity based on the state of engine operation;

internal EGR estimating means for estimating the internal EGR quantity based on the state of engine operation;

target intake valve closing timing calculating means for calculating the target closing timing of the intake valve based on the target air quantity calculated by the aforementioned means for calculating the target air quantity and the internal EGR quantity estimated from the aforementioned means for estimating the internal EGR

quantity; and

intake valve closing timing control means for controlling the closing timing of the intake valve to obtain the target closing timing calculated by the aforementioned means for calculating the target closing timing of the intake valve.

[Claim 3] A variable valve control unit according to Claim 1, characterized in that said means for estimating the internal EGR quantity is configured to estimate the internal EGR quantity by calculating the basic value of the internal EGR quantity based on the target closing timing of the exhaust valve and the engine speed, and when the target closing timing of the exhaust valve and the target opening timing of the intake valve overlap, correcting the basic value in accordance with the overlapped state.

[Claim 4] A variable valve control unit according to Claim 3, characterized in that the amount of correction of the basic value in accordance with the overlapped state is calculated by correcting the basic correction value calculated based on the amount of valve overlap between the target closing timing of the exhaust valve and the target opening timing of the intake valve by the correction coefficient determined based on the intake air pressure and the target closing timing of the exhaust valve.

[Claim 5] A variable valve control unit according to Claim 4, characterized in that the amount of valve overlap used for calculation of the basic correction value is the

value obtained by converting the crank angle period corresponding to the amount of valve overlap into time.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a unit for controlling intake and exhaust valves (variable valve) of an engine, such as a solenoid-type valve, which can variably control the opening and closing timing of the valve as desired, and more specifically, to control the closing timing of the intake valve that is significantly involved in control especially of the intake air quantity and thus of engine torque.

[0002]

[Description of the Related Art]

Hitherto, in the general engines, the intake air quantity is controlled by the opening angle of the throttle valve. Recently, however, there is proposed an engine including solenoid-type intake and exhaust valves for controlling the intake air quantity mainly by controlling the closing timing of the intake valve (See Japanese Patent Laid-Open No. 10-37727).

[0003]

In intake air quantity control of such a type, the target air quantity corresponding to the required torque (required intake air quantity) is achieved by controlling the volume of cylinder intake air corresponding to an

effective intake stroke determined by the closing timing of the intake valve at the intake air pressure that is held approximately constant at the atmospheric pressure in the absence of a throttle valve, and that is determined in dependence on the throttle opening when there is combined a throttle valve.

[0004]

[Problems to be Solved by the Invention]

To control the intake air quantity mainly by the closing timing of the intake valve as described above, the intake valve is to be closed when the piston is at such position that the cylinder contains an amount of fresh air corresponding to the target air quantity in addition to an amount of residual gas (internal EGR quantity) remaining in the combustion chamber. In the case of the aforementioned variable valve, the internal EGR quantity is influenced deeply by the presence or absent of overlap of the intake and exhaust valves and variations in the amount of valve overlap. Especially, variations in internal EGR quantity is significant in the case of variable valves such as a solenoid valve having a high response speed in opening and closing, as the exhaust valve and the intake valve overlap substantially in the fully opened state during a valve overlap period.

[0005]

Accordingly, it has been found that fixed correction or simple correction of the closing timing of the intake

valve corresponding to the target air quantity considering only a prescribed operating condition for the internal EGR quantity is not sufficient for desirable control of an intake air quantity and hence of engine torque. Moreover, even by a system devised to set a target closing timing of the exhaust valve, a target opening timing of the intake valve, and the like according to the operating state to obtain a proper internal EGR quantity and to adjust the target closing timing of the intake valve correspondingly, a desirable control cannot be made as the actual internal EGR quantity varies significantly depending on the factors other than valve timings.

[0006]

With such problems in view, it is an object of the present invention to enable desirable control of intake air quantity and hence of engine torque by controlling the closing timing of the intake valve of the variable valves with a high degree of accuracy.

[0007]

[Means for Solving the Problems]

Therefore, the invention according to Claim 1 is a variable valve control unit being capable of variably controlling the opening and closing timings of the intake and exhaust valves of an engine as desired, characterized in that the control unit is configured to estimate the internal EGR quantity based on the state of engine operation and to control the closing timing of the intake

valve based on the required intake air quantity of the engine and the aforementioned estimated internal EGR quantity.

[0008]

The invention according to Claim 2 is, as shown in Fig. 1, a variable valve control unit being capable of variably controlling the opening and closing timings of the intake and exhaust valves of an engine as desired, including:

target air quantity calculating means for calculating the target air quantity based on the state of engine operation;

internal EGR quantity estimating means for estimating the internal EGR quantity based on the state of engine operation;

target intake valve closing timing calculating means for calculating the target closing timing of the intake valve based on the target air quantity calculated by the aforementioned means for calculating the target air quantity and the internal EGR quantity estimated from the aforementioned means for estimating the internal EGR quantity;

and

intake valve closing timing control means for controlling the closing timing of the intake valve to obtain the target closing timing calculated by the aforementioned means for calculating the target closing

timing of the intake valve.

[0009]

According to the invention as set forth in Claim 1 or Claim 2, the target air quantity is calculated and the internal EGR quantity is estimated for each state of engine operation, then the target closing timing of the intake valve is calculated based on the target air quantity and the internal EGR quantity, and then the closing timing of the intake valve is controlled to the target closing timing.

[0010]

In this arrangement, since the closing timing of the intake valve is corrected and controlled while constantly estimating the internal EGR quantity that is influenced deeply by the presence or absence of overlap of the intake and exhaust valves, variations in the amount of valve overlap and so on according to the state of engine operation, an amount of fresh air corresponding to the target intake air quantity can be obtained and thus torque control with a high degree of accuracy is achieved.

[0011]

The invention according to Claim 3 is characterized in that the aforementioned means for estimating the internal EGR quantity is configured to estimate the internal EGR quantity by calculating the basic value of the internal EGR quantity based on the target closing timing of the exhaust valve and the engine speed, and when the target closing timing of the exhaust valve and the target opening

timing of the intake valve overlap, correcting the aforementioned basic value in accordance with the overlapped state.

[0012]

According to the invention as set forth in Claim 3, the internal EGR quantity is estimated by calculating the basic value of the internal EGR quantity in a state in which there is no overlap exists between the intake and exhaust valves based on the target closing timing of the exhaust valve and the engine speed, and when they are overlapped, correcting the aforementioned basic value according to the overlapped state as the internal EGR quantity increases due to blowing back of gas or the like.

[0013]

In this arrangement, since the basic value of the internal EGR quantity in a state in which there is no overlap exists between the intake and exhaust valves may vary to some extent depending on the engine speed though it is roughly determined by the closing timing of the exhaust valve, considering the engine speed allows calculation with a high degree of accuracy and correcting the basic value in accordance with the overlapped state allows estimation of the internal EGR quantity with a high degree of accuracy.

[0014]

The invention according to Claim 4 is characterized in that the amount of correction of the aforementioned basic value in accordance with the overlapped state is

calculated by correcting the aforementioned basic correction value calculated based on the amount of valve overlap between the target closing timing of the exhaust valve and the target opening timing of the intake valve by the correction coefficient determined based on the intake air pressure and the target closing timing of the exhaust valve.

[0015]

According to the invention as set forth in Claim 4, the amount of variations (increased amount) of the internal EGR quantity when the intake and exhaust valves overlap with respect to the basic value varies because the amount of gas blown back varies with the closing timing of the exhaust valve or with the intake air pressure even when the amount of valve overlap is constant. Accordingly, the final amount of correction with respect to the basic value is determined by calculating the basic correction value to be calculated based on the amount of valve overlap while correcting by the correction coefficient determined based on the intake air pressure and the target closing timing of the exhaust valve.

[0016]

As a consequent, the internal EGR quantity may be estimated with a higher degree of accuracy.

The invention according to Claim 5 is characterized in that the amount of valve overlap used for calculation of the aforementioned basic correction value is the value

obtained by converting the crank angle period corresponding to the amount of valve overlap into time.

[0017]

According to the invention as set forth in Claim 5, since variations in the internal EGR quantity due to overlap between the intake and exhaust valves is generated during the overlapping period, the basic correction value is calculated by the use of the value obtained by converting the crank angle period corresponding to the amount of valve overlap into time.

[0018]

This allows accurate calculation of the basic correction value.

[0019]

[Detailed Description of Preferred Embodiments]

An embodiment of the present invention will be described below.

Fig. 2 is a system drawing of an engine provided with a variable valve control unit according to an embodiment of the present invention.

[0020]

A combustion chamber 3 defined by a piston 2 of each cylinder of an engine 1 is provided with an intake valve 5 and an exhaust valve 6 of solenoid-type so as to surround an ignition plug 4. The reference numeral 7 designates an air intake passage and the numeral 8 designates an exhaust passage.

[0021]

A basic structure of a solenoid actuator for the intake valve 5 and the exhaust valve 6 (which constitutes a variable valve with the intake valve and the exhaust valve) is shown in Fig. 3. A plate-shaped movable element 22 is attached on a valve stem 21 of a valve body 20, and the movable element 22 is urged to a neutral position by springs 23, 24. An opening solenoid coil 25 is disposed below the movable element 22, and a closing solenoid coil 26 is disposed above the same.

[0022]

Before starting the engine 1, the opening solenoid coil 25 and the closing solenoid coil 26 are energized alternately to oscillate the movable element 22 resonantly. When the amplitude is increased sufficiently, the movable element 22 is attracted and held by any one of solenoid coils.

[0023]

Subsequently, the valve is opened from a closed state by deenergizing the upper opening solenoid coil 26 that attracts the movable element 22 to allow the movable element 22 to move downward by an urging force of the spring 23, and, attracting the movable element 22 by energizing the lower opening solenoid coil 25 when the movable element 22 is positioned in close proximity of the opening solenoid coil 25. Accordingly, the valve body 20 is lifted and thus the valve is opened.

[0024]

On the other hand, the valve is closed from an opened state by deenergizing the lower opening solenoid coil 25 that attracts the movable element 22, moving the movable element 22 upward by a urging force of the spring 24, attracting the movable element 22 by energizing the upper closing solenoid coil 26 when the movable element 22 is positioned in close proximity of the closing solenoid coil 26. Accordingly, the valve body 20 is seated on the seat portion and thus the valve is closed.

[0025]

Referring back to Fig. 2, the intake passage 7 is provided with an airflow meter 14 for detecting the intake air quantity and a throttle valve 15 whereof the opening is controlled electronically. A solenoid-type fuel injection valve 9 is provided at the portion of an air intake port of each cylinder.

[0026]

Here, a control unit 10 controls the operation of the intake valve 5, the exhaust valve 6, the throttle valve 15, the fuel injection valve 9, and the ignition plug 4. The control unit 10 is supplied with signals from a crank angle sensor 11 that is capable of supplying a crank angle signal simultaneously with the rotation of the engine thereby detecting the engine speed, an accelerator pedal sensor 12 for detecting the accelerator opening (the degree of depressing the accelerator pedal), and the like.

[0027]

The intake air quantity is controlled mainly by the control of the closing timing of the intake valve 5 so that the target torque is achieved based on the state of engine operation such as the accelerator opening, the engine speed, and so on. The closing timing of the exhaust valve 6 and the opening timing of the intake valve 5 (and hence the opening timing of the exhaust valve 6) are controlled so that adequate control of the internal EGR quantity is achieved in accordance with the operating conditions in order to reduce the exhaust emission, especially the amount of NOx exhaust. However, in fact, the internal EGR quantity varies also by the factors other than such valve timings, and thus the internal EGR quantity is estimated for each operating condition and the closing timing of the intake valve 5 is controlled by being corrected in accordance with the estimated internal EGR quantity.

[0028]

The intake air quantity is detected based on the values detected by the aforementioned various sensors, and the fuel injection quantity from the aforementioned fuel injection valve 9 is controlled based on the intake air quantity.

Referring now to the drawings, an embodiment of control of the closing timing of the intake valve according to the present invention will be described. Fig. 4 is a flow chart of a main routine.

[0029]

In Step 1, the accelerator opening detected by the accelerator pedal sensor 12, the engine speed detected by the crank angle sensor 11, and the like are read and a target air quantity FQH0EM appropriate to required torque is calculated.

[0030]

In Step 2, the basic value EVEGR0 of the internal EGR quantity in a state in which there is no overlap between the intake and exhaust valves is calculated. The calculation is performed according to the subroutine shown in Fig. 5. In other words, the engine speed Ne and the target closing timing of the exhaust valve (EVC) are read in Steps 21, 22, and in Step 23, a map table created based on characteristic data shown in Fig. 8 is searched based on the value obtained in Steps 21, 22, and the basic value EVEGR0 of the internal EGR quantity is calculated as a EGR rate with respect to the aforementioned target air quantity FQH0EM. The basic value EVEGR0 is a burned gas quantity remaining in the cylinder in a state in which there is no overlap between the intake and exhaust valves. Therefore, as the cylinder volume that is determined by the position of the piston at the closing timing of the exhaust valve EVC becomes smaller, the basic value EVEGR0 decreases, and the basic value EVEGR0 becomes smallest at exhaust top dead center as shown in Fig. 8. However, even when the position of the piston is the same, the exhaust valve is closed in a

state in which remaining gas is somewhat compressed when the EVC is before exhaust top dead center (hereinafter referred to as BTDC as appropriate). On the other hand, when the EVC is after exhaust top dead center (hereinafter referred to as ATDC as appropriate), the exhaust valve is closed while pulling back exhaust air, which was once discharged to the exhaust passage, into the cylinder. Therefore in the latter case, the remaining gas quantity or the internal EGR quantity decreases due to delay in return of exhaust gas. Since this tendency is attributed to the inertia, it varies with the engine speed Ne as well. The inertia increases with increase in engine speed Ne, and thus the influence exerted on the internal EGR quantity increases. Especially when the exhaust EVC is at ATDC, the influence of the inertia is significant as the exhaust gas flow changes, and thus the decrease of the internal EGR quantity due to increase in engine speed Ne increases. At the position away from exhaust top dead center, the piston speed is higher, and thus variations of the internal EGR quantity with respect to variations in engine speed Ne increase.

[0031]

Referring back to Fig. 4, in Step 3, whether or not there is overlap between the target closing timing EVC of the exhaust valve 6 and the target opening timing IVO of the intake valve 5 is determined.

When it is determined that there is no valve overlap,

the control unit 10 proceeds to Step 4, and the correction amount OLEGR1 of the internal EGR quantity due to valve overlap is set to zero. Accordingly, the internal EGR quantity is set to the aforementioned basic value EVEGR0.

[0032]

When it is determined that there is overlap between the intake and exhaust valves in Step 3, the control unit 10 proceeds to Step 5 and calculates the basic correction value OLEGR0 for the case where the valves are being overlapped.

The calculation is performed in accordance with a subroutine shown in Fig. 6.

[0033]

In other words, in Steps 31, 32, 33, the control unit 10 reads the engine speed Ne, the target closing timing EVC of the exhaust valve 6, and the opening timing IVO of the intake valve 5 sequentially, and then in Step 34, converts the amount of overlap (crank angle period) into the overlap time OLTIME with the following equation based on these input values.

[0034]

OLTIME = (EVC - IVO)/Ne

Subsequently, in Step 35, the control unit 10 searches the value OLEGC0 that is predetermined corresponding to the overlap time OLTIME based on the aforementioned overlap time OLTIME in the map table.

[0035]

In Step 36, whether the target closing timing EVC of the exhaust valve 6 is at BTDC or at ATDC is determined.

When it is determined that the EVC is at BTDC in Step 36, the control unit 10 proceeds to Step 37, and set the value OLEGC0 searched in the aforementioned step 35 as a basic correction value OLEGR0 for the case where the valves are being overlapped without change.

[0036]

On the other hand, when it is determined that the EVC is at ATDC in Step 36, the control unit 10 proceeds to Step 38 and sets the value obtained by correcting the aforementioned searched value OELEGC0 in accordance with the target closing timing EVC by the use of the equation shown below as a basic correction value OLEGR0 for the case where the valves are being overlapped.

[0037]

OLEGR0 = OLEGC0 - EVC (phase lag after top dead center) x constant

Variations (increased amount) of the internal EGR quantity with respect to the basic value when the intake and exhaust valves are overlapped vary even for the same amount (time) of valve overlap because the influence of backflow differs depending on the closing timing of the exhaust valve EVC, for example. Fig. 9 shows variations in the increased amount of the internal EGR quantity with respect to the EVC for a plurality of overlap amounts (time) under the constant engine speed Ne and the constant

intake air pressure. As shown in the figure, when it is determined that the EVC is at BTDC, the increased amount of the internal EGR quantity due to valve overlap is held substantially constant irrespective of EVC. It is because when the EVC is at BTDC, burned gas in the cylinder tends to be sucked back into the intake port on the lower pressure side during the valve overlap, rather than being expelled into the exhaust port, and the backflow becomes dominant. Then the burned gas of the backflow to the intake port is sucked again in the subsequent intake stroke, so that the EGR rate is substantially constant. Therefore, the correction by EVC (the advance quantity before top dead center) is not performed as in the aforementioned Step 36.

[0038]

On the other hand, when it is determined that the EVC is at ATDC, the quantity of exhaust backflow into the intake port decreases because of downward movement of the piston during the valve overlap. Moreover, as the EVC is moved away from top dead center, the intake negative pressure in the cylinder increases and the pressure difference from the intake negative pressure in the intake port decreases, and thus the tendency to the exhaust backflow decreases. In the overlapped state, as compared to the non-overlapped state, the quantity of return flow of exhaust gas from the exhaust port into the cylinder increases (thus the scavenging efficiency decreases) by transmission of the intake negative pressure into the

cylinder through the opening of the intake valve, and the internal EGR quantity increases correspondingly. However, it seems that this increased quantity becomes large when the valve overlap period is near top dead center, but decreases as the valve overlap period moves away from top dead center. In other words, when the overlap period is near top dead center, the influence from the intake negative pressure in the cylinder exerted on the condition in the cylinder is greater than the non-overlapped state where the intake valve is not opened, and thus the increased amount of the internal EGR quantity due to return of exhaust gas is large. On the other hand, when the valve overlap period is away from top dead center, the difference between the intake negative pressure in the cylinder increased by the downward movement of the piston in the non-overlapped state where the intake valve is held closed during this period, and the intake negative pressure transmitted from the intake port into the cylinder due to valve overlap becomes smaller, and thus the difference in the quantity of return flow of exhaust gas between the overlapped state and the non-overlapped state decreases. In other words, the increased amount of the internal EGR quantity due to the return flow of exhaust gas due to valve overlap decreases as the valve overlap period (or EVC) moves away from top dead center.

[0039]

From these reasons, as shown in Fig. 9, when the EVC

is at ATDC, the increased amount of the internal EGR quantity due to valve overlap decreases as the EVC moves away from top dead center.

[0040]

Therefore, as in the aforementioned Step 37, the control unit 10 performs the subtraction that is proportional to the EVC (phase lag after top dead center).

Referring back to Fig. 4, in Step 6, a correction coefficient OLEGCB for correcting the basic correction value OLEGR0 during overlap period calculated as described above in accordance with the intake air pressure (boost pressure) is calculated.

[0041]

In other words, the aforementioned basic correction value OLEGR0 is calculated as an increased amount of the internal EGR quantity during overlap period under the constant intake air pressure (-50 mmHg). However, even when the amount of valve overlap (time) and the EVC are the same, the quantity of backflow during the valve overlap period or the like varies with variations in the intake air pressure. Therefore, correction according to the intake air pressure is required. In other words, correction is not necessary when the intake air pressure is held constant approximately at the atmospheric pressure without provision of a throttle valve. However, when the amount of intake air is controlled by the closing timing of the intake valve 5 after controlling the intake air pressure at a

predetermined level by throttling the opening of the aforementioned throttle valve 15 adequately in the case where the vacuum pressure for braking or the intake negative pressure for sucking evaporated fuel or blow-by gas into the intake system are necessary, the aforementioned correction based on the intake air pressure is needed.

[0042]

Calculation of the correction coefficient OLEGCB in accordance with the intake air pressure is performed according to the subroutine shown in Fig. 7. That is, in Step 41, the control unit 10 reads the target intake air pressure calculated during the control of the intake air pressure by controlling the opening of the aforementioned throttle valve, and in Step 42, it reads the target closing timing EVC of the exhaust valve 6. In Step 43, the control unit 10 searches a map table created based on characteristic data as shown in Fig. 10 based on data read in Steps 41 and 42 and then searches the correction coefficient OLEGCB in accordance with the intake air pressure. Fig. 10 shows multiplying factors of the increased amount of the internal EGR quantity under the intake air pressure (negative pressure) of -100 mmHg and -300 mmHg, with respect to the increased amount of the internal EGR quantity under the intake air pressure of -50 mmHg (four different data for two valve overlap lengths [crank angles] of 20° and 40°). As shown in the figure,

when the intake air pressure is -100 mmHg, the multiplying factor remains constant at about two irrespective of variations in EVC (the middle of the valve overlap period). On the other hand, when the intake air pressure is -300 mmHg, the multiplying factor is substantially constant in the order of three to four when EVC is at BTDC, but when EVC is at ATDC, the multiplying factor is proportionally increased as EVC moves away from top dead center. When EVC is at ATDC at a constant intake air pressure (-50 mmHg), as mentioned before, the pressure difference in the cylinder due to the presence or absence of valve overlap decreases as EVC is moved away from top dead center, so that the increased amount of the exhaust backflow tends to decrease. However, when the intake negative pressure increases to -300 mmHg, the pressure difference in the cylinder due to the presence or absence of valve overlap increases, so that the increased quantity is held at a high level, and thus the multiplying factor is increased as compared to the example of -50 mmHg.

[0043]

Referring back to Fig. 4, in Step 7, the basic correction value OLEGR0 calculated in Step 5 is multiplied by the correction coefficient OLEGCB corresponding to the intake air pressure calculated in Step 6 to calculate the final correction amount OLEGR1 of the internal EGR quantity during valve overlap period.

[0044]

In Step 8, the basic value EVEGR0 of the internal EGR quantity calculated in Step 2 is added with the correction amount OLEGR1 during overlap period calculated in this way for correction to estimate the final internal EGR quantity EGRREM (See the equation below).

[0045]

EGRREM = EVEGR0 + OLEGR

Subsequently, in Step 9, the target air quantity correction value HQHOFM is calculated by correcting the target air quantity FQH0EM calculated in Step 1 based on the aforementioned internal EGR quantity (See the equation below). This correction is not intended to modify the target air quantity itself. It is just an expediential correction to take account of variations of the closing timing of the intake valve for obtaining the target air quantity (the quantity of fresh air) caused by the internal EGR quantity. In other words, a total amount of gas in the cylinder obtained by adding the internal EGR quantity to the target air quantity is calculated as the target air quantity.

[0046]

HQHOFM = FQH0EM x (1+EGRREM)

In Step 10, the target closing timing IVC of the air intake valve 5 is calculated based on the aforementioned target air quantity correction value HQHOFM.

[0047]

Accordingly, a control signal corresponding to the

aforementioned target closing timing IVC is output to the aforementioned solenoid actuator, and the intake valve 5 is controlled to be closed at the target closing timing IVC.

In such an arrangement, the closing timing of the intake valve is corrected and controlled while estimating the internal EGR quantity that varies significantly by the presence or absence of overlap between the intake and exhaust valves, variations in valve overlap time, or the like according to the state of engine operation from point to point. Therefore, the amount of fresh air suitable for the target intake air quantity can be obtained, and thus torque control with a high degree of accuracy is achieved.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a block diagram showing a construction and a function of the present invention.

[Fig. 2]

Fig. 2 is a system drawing of an engine provided with a movable valve control unit showing an embodiment of the present invention.

[Fig. 3]

Fig. 3 is a drawing showing a basic structure of a solenoid actuator for intake and exhaust valves.

[Fig. 4]

Fig. 4 is a flowchart showing a target closing timing setting routine for the intake valve according to the embodiment.

[Fig. 5]

Fig. 5 is a flow chart of a subroutine for calculating the basic value of the internal EGR quantity (value in the non overlapped state).

[Fig. 6]

Fig. 6 is a flowchart of a subroutine for calculating the basic correction value for the internal EGR quantity in the case where the valves are being overlapped.

[Fig. 7]

Fig. 7 is a flowchart of a subroutine for calculating the correction coefficient for the aforementioned basic correction value in accordance with the intake air pressure.

[Fig. 8]

Fig. 8 is a drawing showing a characteristic of the basic value of the aforementioned internal EGR quantity.

[Fig. 9]

Fig. 9 is a drawing showing a characteristic of the basic correction value in the case where the valves are being overlapped.

[Fig. 10]

Fig. 10 is a drawing showing an influence of the intake air pressure on the aforementioned basic correction value.

[Reference Numerals]

1 engine

5 intake valve

9 fuel injection valve

10 control unit

11 crank angle sensor

12 accelerator pedal sensor

[Name of Document] ABSTRACT

[Abstract]

[Object] To improve the performance of the intake air quantity control.

[Solving Means] The controller calculates the basic value of the internal EGR quantity under the condition without valve overlap (S2). When there is a valve overlap period, the increased amount to be corrected due to overlap calculated in consideration of the amount of valve, the position of the central crank angle thereof, and the intake air pressure (S5, S6, S7) is added to the aforementioned basic value to obtain the internal EGR quantity (S8). Then, the target closing timing of the intake valve is calculated for the target air quantity correcting value obtained by adding the aforementioned internal EGR quantity on the calculated target air quantity (S1). This allows accurate estimation of the internal EGR quantity and accurate control of intake air quantity by the closing timing of the intake valve.

[Selected Figure] Fig. 4

Figures

[Fig. 1]

1. means for calculating target air quantity

2. means for estimating internal EGR quantity

3. means for calculating target closing timing of intake valve

4. means for controlling closing timing of intake valve

[Fig. 4]

S1 calculates target air quantity FQHOEM

S2 calculates basic value of internal EGR quantity EVEGR0

S3 O/L exist or not?

yes

S4 OLEGR1=0

no

S5 calculates basic correction value for O/L OLEGR0

S6 calculates intake air pressure correction coefficient OLEGCB

S7 OLEGR1=OLEGR0xOLEGCB

S8 calculates internal EGRR quantity
EGRREM=EVEGR0+OREGR1

S9 calculates target air quantity correction value
HQH0EM=FQHOEMx(1+EGRREM)

S10 calculates target closing timing of intake valve IVC

[Fig. 5]

S21 reads engine speed Ne

S22 reads target EVC

S23 calculates basic value of internal EGR quantity EVEGR0

[Fig. 6]

S31 reads engine speed Ne

S32 reads target EVC

S33 reads target IVO

S34 calculates overlap length

OLTIME=(EVC-IVO)/Ne

S35 calculates OELGC0 based on OLTIME

S36 EVC:BTDC?

S37 OLEGR0=OLEGC0

S38 OLEGR0=OLEGC0-EVC x constant

[Fig. 7]

S41 reads target intake air pressure

S42 reads target EVC

S43 calculates intake air pressure correction coefficient OLEGCB

[Fig. 8]

1. Base value of internal EGR quantity (EGR rate)
2. phase lag after top dead center (ATDC)

3. ←top dead center→

4. CLOSING TIMING OF EXHAUST VALVE (EVC)

5. advanced timing before top dead center (BTDC)

6. Ne high Ne high

[Fig. 9]

1. increased amount of internal EGR quantity (EGR rate)

2. phase lag at ATDC

3. ←top dead center→

4. CLOSING TIMING OF EXHAUST VALVE (EVC)

5. advanced timing at BTDC

6. intake air pressure constant

7. O/L time ... longer

[Fig. 10]

1. multiplying factor for the intake air pressure -50 mmHg

2. phase lag at ATDC

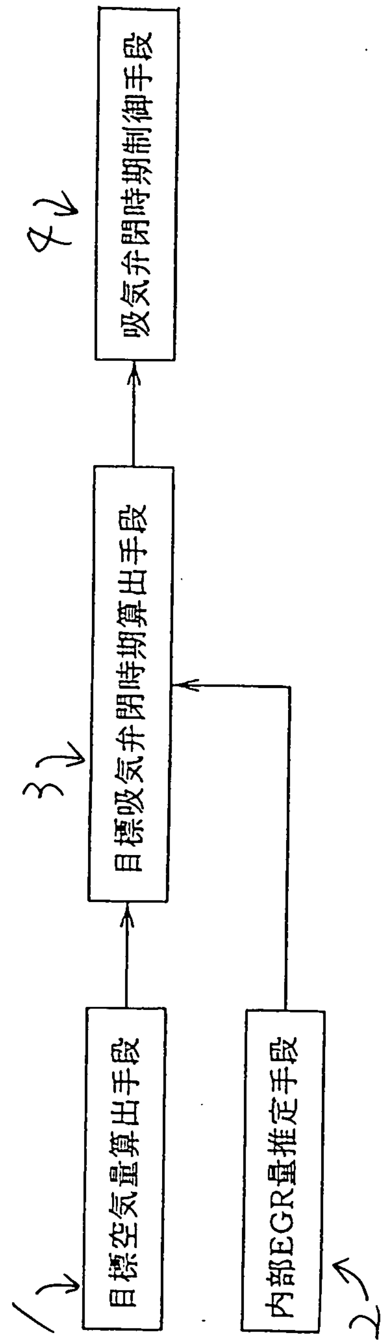
3. ←top dead center→

4. advanced timing at BTDC

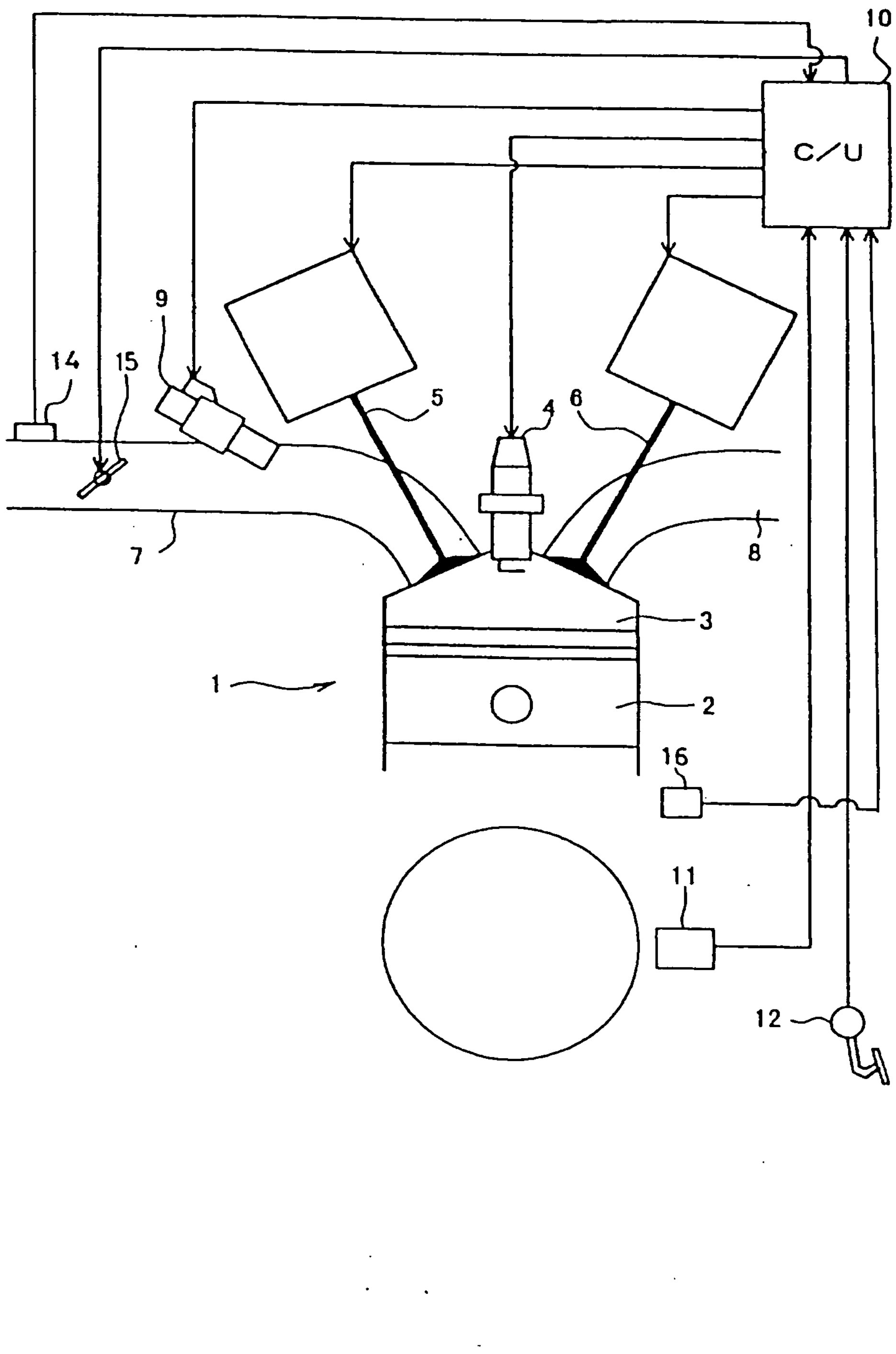
5. CLOSING TIMING OF EXHAUST VALVE (EVC)

【書類名】　図面

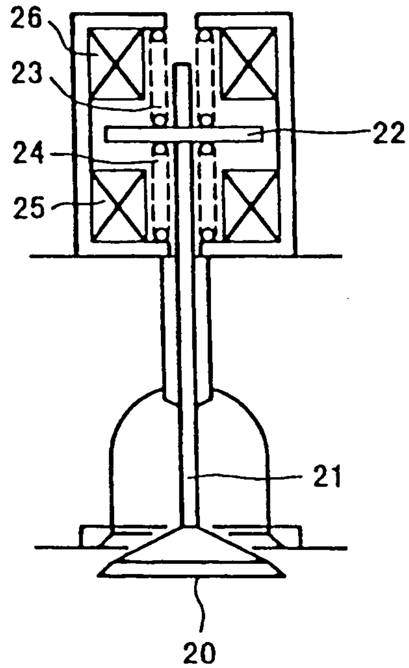
【図１】



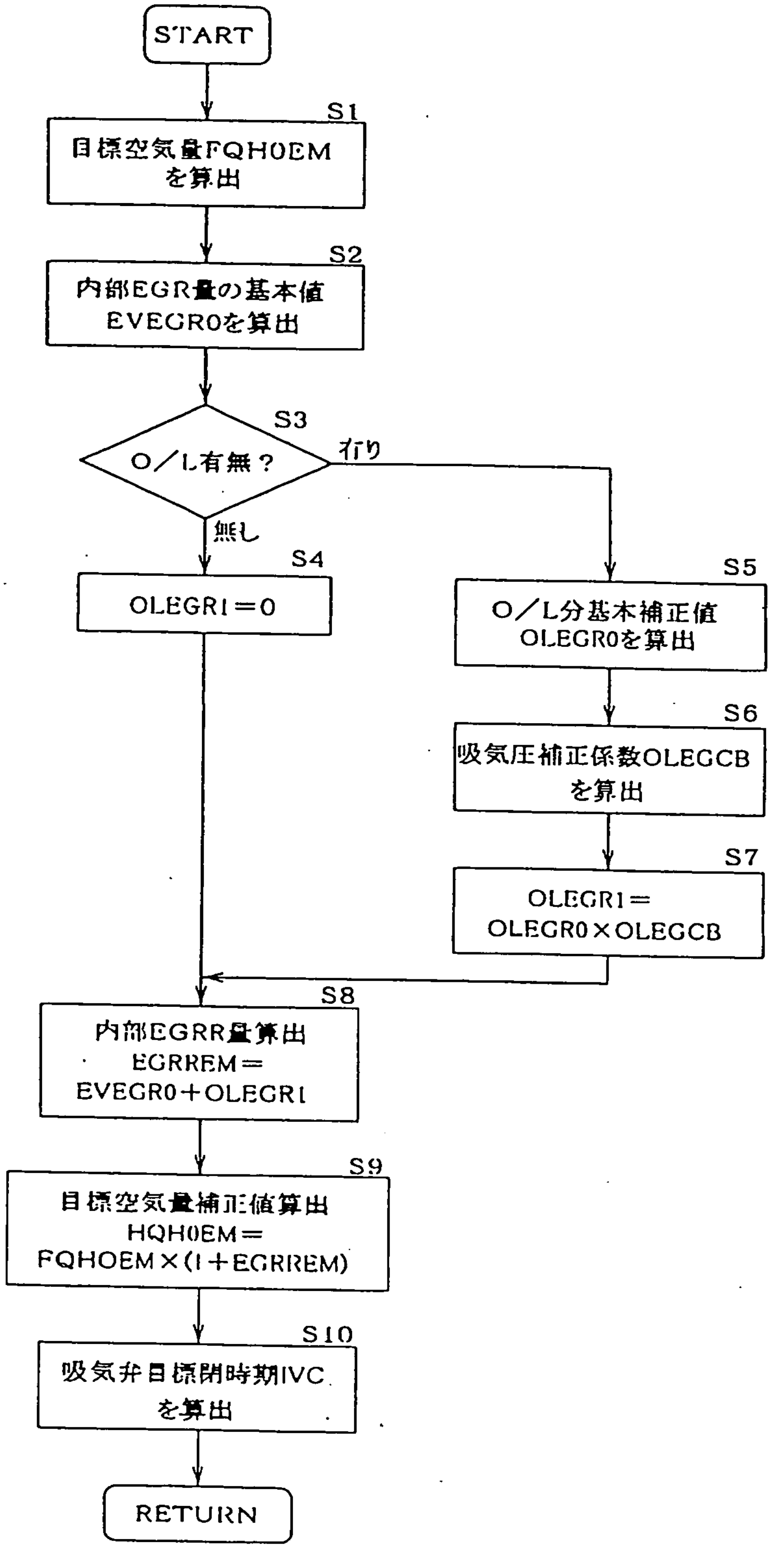
【図２】



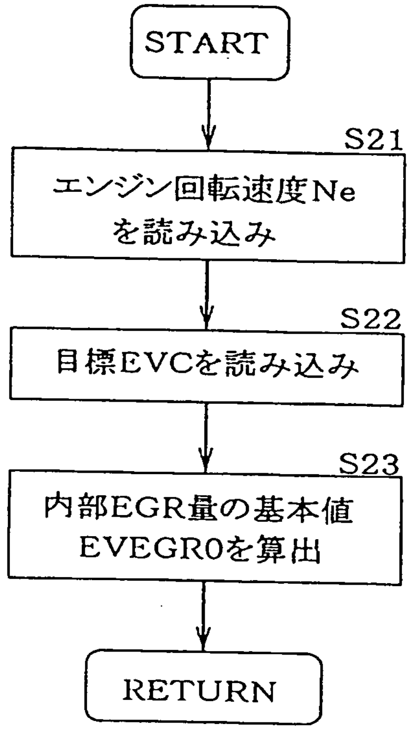
【図３】



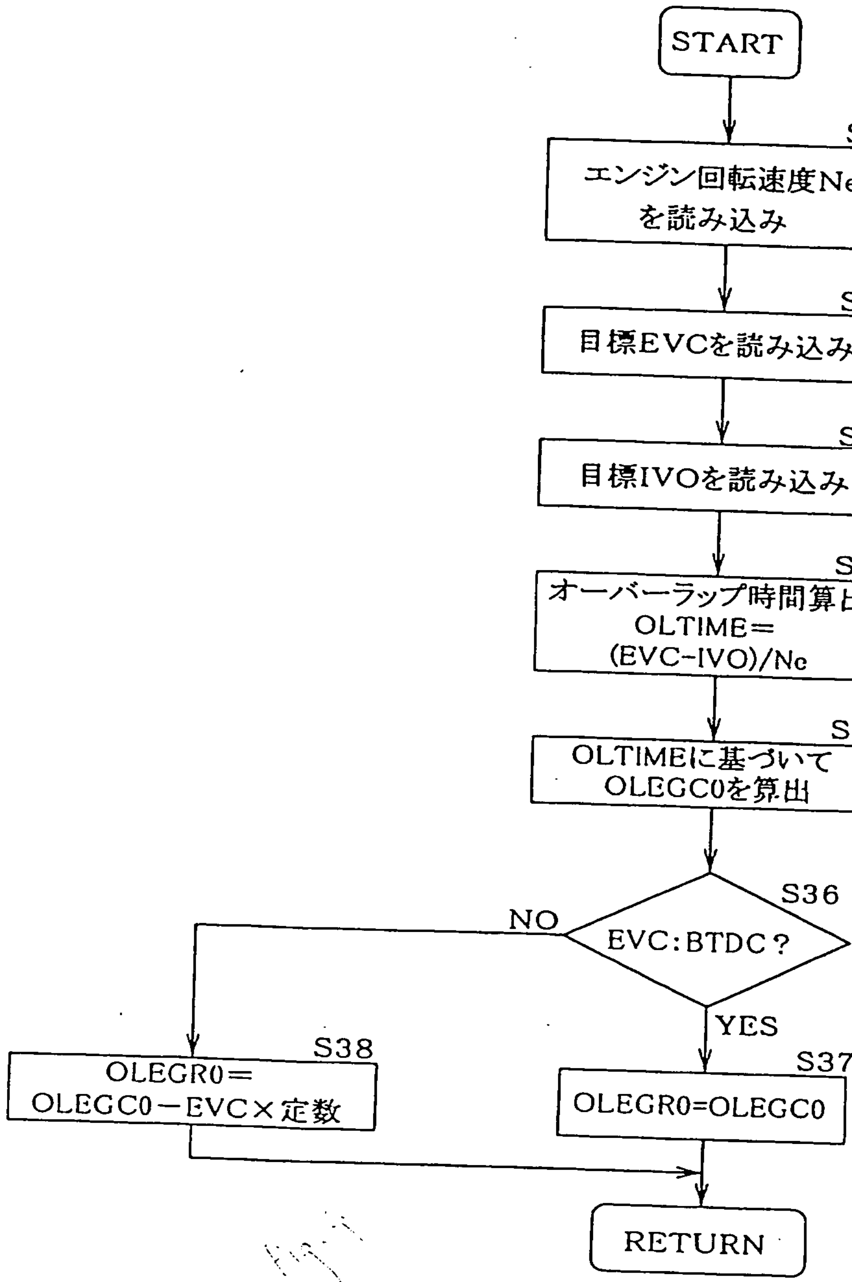
【図４】


START
S1
目標空気量FQHOEM
を算出
S2
内部EGR量の基本値
EVEGR0を算出
S3
O／L有無？
有り
無し
S4
OLEGR1＝0
S5
O／L分基本補正値
OLEGR0を算出
S6
吸気圧補正係数OLEGCB
を算出
S7
OLEGR1＝
OLEGR0×OLEGCB
S8
内部EGRR量算出
EGRREM＝
EVEGR0＋OLEGR1
S9
目標空気量補正値算出
HQH0EM＝
FQHOEM×(1＋EGRREM)
S10
吸気弁目標閉時期IVC
を算出
RETURN

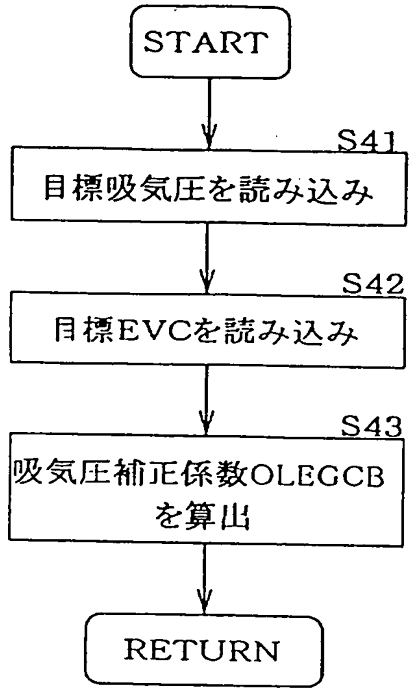
【図５】


START
S21
エンジン回転速度Ne
を読み込み
S22
目標EVCを読み込み
S23
内部EGR量の基本値
EVEGR0を算出
RETURN

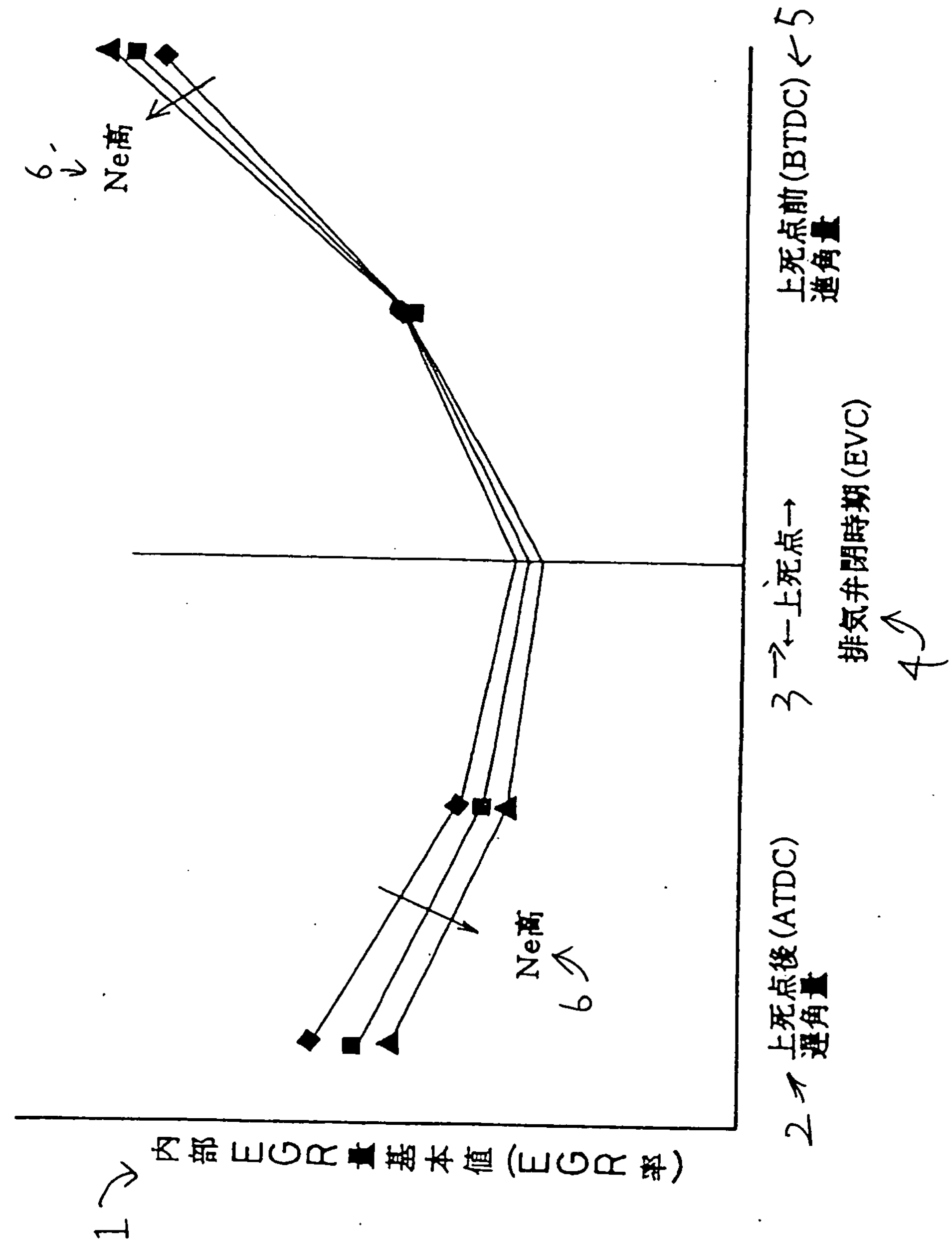
【図６】


START
S31
エンジン回転速度Ne
を読み込み
S32
目標EVCを読み込み
S33
目標IVOを読み込み
S34
オーバーラップ時間算出
OLTIME＝
(EVC−IVO)/Ne
S35
OLTIMEに基づいて
OLEGC0を算出
S36
EVC:BTDC？
NO
YES
S37
OLEGR0=OLEGC0
S38
OLEGR0＝
OLEGC0－EVC×定数
RETURN

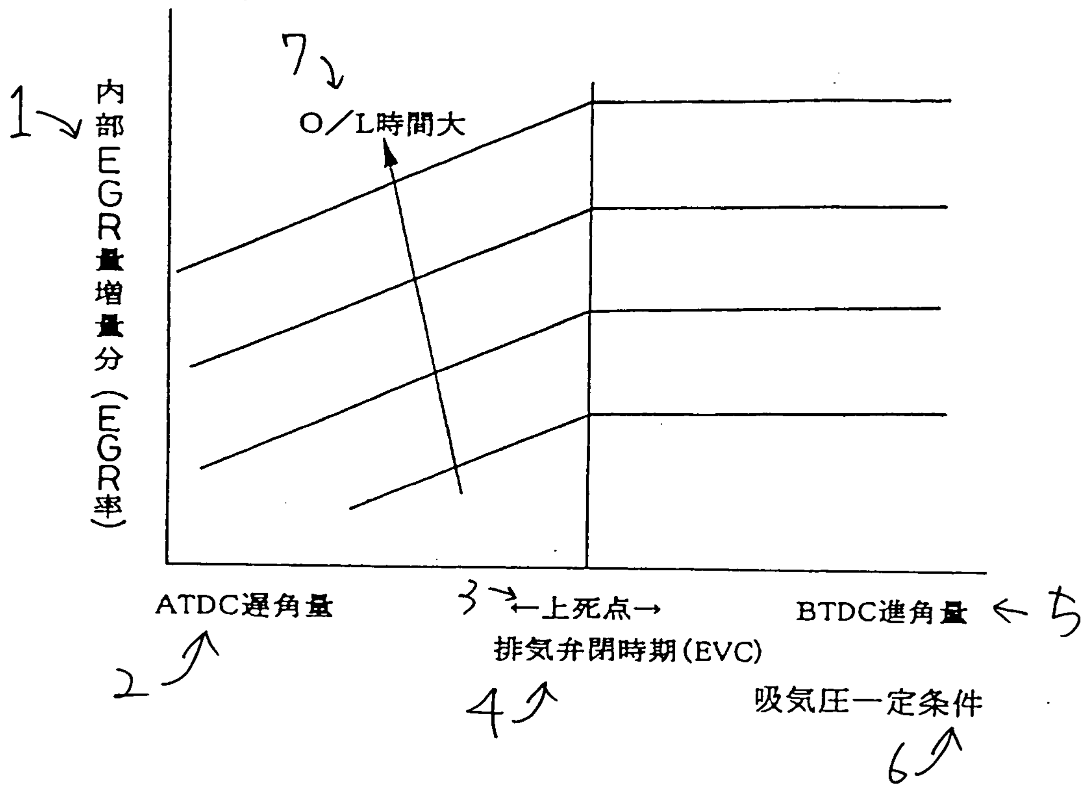
【図７】


START
S41
目標吸気圧を読み込み
S42
目標EVCを読み込み
S43
吸気圧補正係数OLEGCB
を算出
RETURN

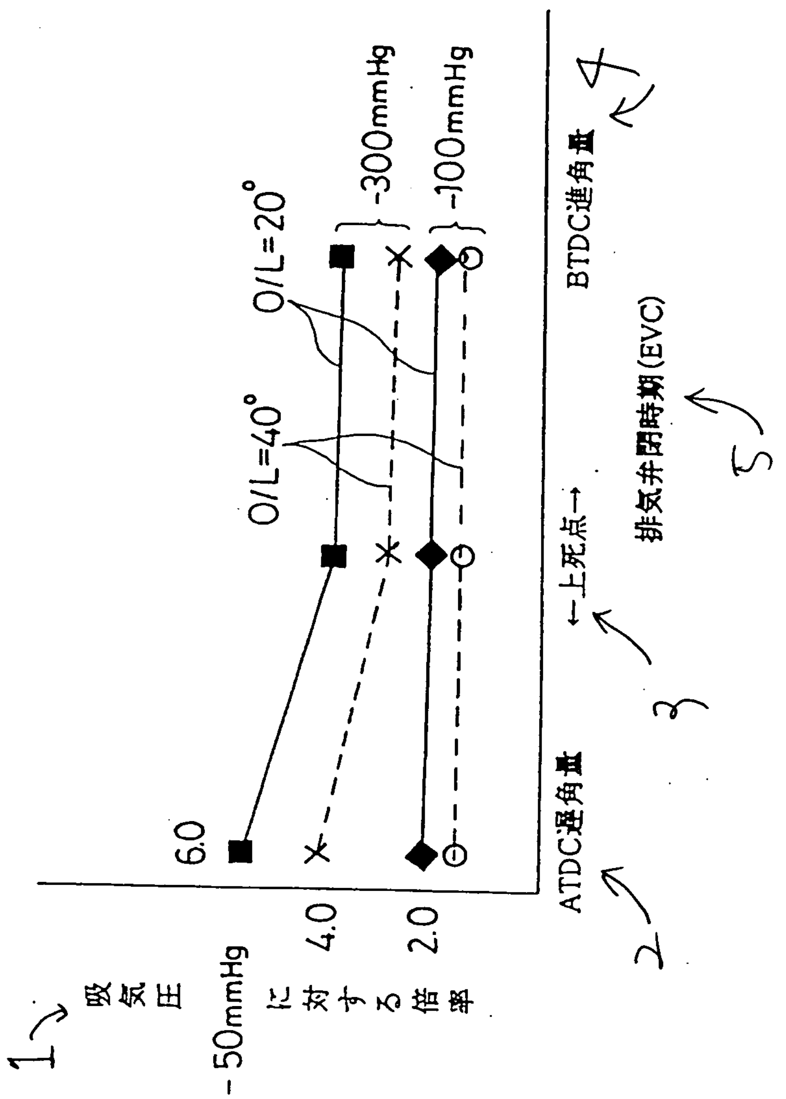
【図８】


内部ＥＧＲ量基本値(ＥＧＲ率)
上死点後(ATDC)
遅角量
上死点
上死点前(BTDC)
進角量
排気弁開時期(EVC)
Ne高
Ne高
1
2
3
4
5
6
6

【図９】


1
内部EGR量増量分（EGR率）
7
O／L時間大
ATDC遅角量
2
3
←上死点→
排気弁閉時期(EVC)
4
BTDC進角量
5
吸気圧一定条件
6

【図１０】



吸気圧-50mmHgに対する倍率
6.0
4.0
2.0
O/L=20°
O/L=40°
-300mmHg
-100mmHg
ATDC遅角量
←上死点→
BTDC進角量
排気弁閉時期(EVC)
1
2
3
4
5